Sandia National Laboratories

MFG S&T Quarterly

MFG Science & Technology That Makes a Difference

August 2004—Vol. 2 No. 4

Mill/Turn Manufacture of Air-Launched Cruise Missile Access Door

Continuation of "The Manufacturing Enterprise Keeps Pace with New Technology" featured in the MFG S&T Quarterly May 2003.

The Manufacturing Enterprise's (ME) new 5-axis mill/turn-multi-tasking machining centers continue fabricating geometrically complex components. With this new technology (a combination horizontal turning and multi-axis milling machine) the ME, primarily through reduced machining set-ups, has saved its customers 30%-70% on schedules and costs.

One project that challenged the ME was an access door for the Air-Launched Cruise Missile (ALCM) for the W80 System Design Qualification department (08242). The W80 warhead is designed to be carried by the ALCM and the Advanced Cruise Missile (ACM) on the B-52H aircraft. The W80 is currently undergoing a Life Extension Program (LEP) that includes modifications to the warhead system. In an effort to better understand the impact of the flight environment on the weapon system, a series of captive carry (defined as captive to the aircraft and not launched) tests have been designed to obtain complex warhead environmental data not readily obtainable through ground testing. Multiple tests on each missile platform are scheduled between May and August 2004.

The captive carry tests have been designed to be self contained within the missile and include a solid-state data recording system and batteries. It is mounted onto the missile payload bay door. Because of the additional mass of these components, a new payload bay access door had to be designed with sufficient structural integrity. The external contour of the ALCM access door was of a complex geometry that required specialized machinery.

Walter McLain displays ALCM access door

The ME was approached by the Engineering Services department to inquire if it could meet the delivery timeline of this project. The access door is a large component with intricate detail and curvature that requires multi-axis machining. Without the new mill/turn-multi-tasking machining centers project timelines could not have been met, because machining of this door would have required a large 5-axis CNC mill which was non-operational at the time; another smaller 5-axis mill in the shop would have required multiple set-ups per side and the lack of high speed machining capability on this machine would have lengthened delivery time of doors.

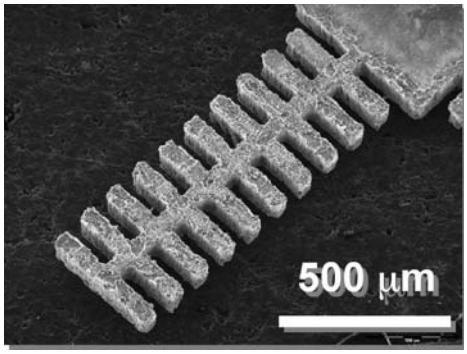
Machining began with the manufacture of a set-up piece for fit check, design validation, and NC program verification that required 140 hours of machining with numerous in-process design iterations as project requirements were evolving. The access door proved to be a challenge as

ALCM Door, Continued, page 2

Scanning New Territory with Femtosecond Laser

One of the most innovative tools being utilized in mesoscale manufacturing is the femtosecond laser. The Mfg. S&T Center's Manufacturing Engineering and Process Development department and the Ceramics and Glass department have been performing research on the laser's potential capabilities. Sponsored by an Advanced Manufacturing Laboratory Directed Research and Development (LDRD) investment, this research has provided a greater understanding of short pulse laser machining characteristics and has produced an expanding customer base.

The unique micromachining capabilities of the femtosecond laser are a result of its extremely short pulse duration—approximately 75 fs (75×10^{-15} s) or 75 quadrillionths of a second. The very high peak power that is contained in this ultra short pulse of light is not absorbed by the work piece and does not exhibit the thermal load that is normally associated with laser processing. Instead, the femtosecond pulse ablates the material by disrupting the forces that hold atoms together. It is now possible for designers to envision meso scale features as small as 12 µm that can be routinely processed in materials of widely differing compositions. Additionally, the 800 nm Ti-Sapphire laser can be focused to directly create three-dimensional features within the interior of materials that are transparent to this wavelength of energy.



A detail of a meso-scale windmill machined with a femtosecond laser.

The Center has been working with departments in the Weapons Systems and Science and Technology divisions to probe new applications for femtosecond laser machining. One new activity has been the machining of thin film energetic materials. Intricate patterns can be machined into these materials without the

Femto/Laser, Continued, page 3

Tech Updates

Sandia to Lead A Multi-Site LENS® Qualification Effort

Laser Engineered Net Shaping™ (LENS®) is a metal deposition process developed at Sandia National Laboratories, with key R&D activities ongoing in the Manufacturing Engineering and Process Development department. The LENS process utilizes a laser and powdered metal to create free-form, 3-D metal components. Members of the department recently teamed with Materials and Engineering Sciences, Materials and Process Sciences, and Surety Assessments departments to lead a proposal submitted to the NNSA Advanced Design and Production Technology program for the Qualification of LENS as a Modification and Repair Capability for the Responsive Infrastructure initiative.

The team leaders gathered collaborators from the Kansas City Plant, BWXT Y-12, BWXT Pantex, and Savannah River National Laboratory with the shared goal of qualifying LENS for the repair or modification of weapon and tooling components. The project will include reviews of quality procedures and business practices by the partner sites and product engineers. Each site will then provide candidate components or tooling that will be modified by the LENS process and returned to the partner sites for evaluation. The selection of this proposal will expose partner sites, component designers, and process engineers to the capabilities of the LENS process while also providing them with confidence regarding the quality and acceptance potential of LENS modified components. The Sandia organizations will undertake further process development and materials testing to provide process capability data for the quality evaluations. The two-year project will provide $1.425M for Sandia and a total of $2.725M to the Nuclear Weapons Complex for this qualification effort.

LENS Deposited Bracket

Laser Engineered Net Shaping™ is a trademark and LENS® is a registered trademark of Sandia Corporation.

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ALCM Door

Continued from page 1

the ME encountered some hurdles along the way: full 5-axis machining/contouring difficulties, laser diameter and tool length measurement system reliability issues, B-axis spline and coupling lock down positional repeatability, and high speed machining options that were not available with C-axis moves. These issues had not arisen before, primarily because a part with this complexity had not been manufactured by these machine tools. Once the issues were resolved and the operational parameters understood, the access door project was completed and delivered per schedule.

Rough machining of this component was done using a 2-flute 1.5" diameter inserted end mill taking a 0.125" depth of cut at 9000 RPM and traveling at 500 IPM. Total roughing time required 5 hours per part. Final finish machining was done using a ball end to accommodate curved surfaces, as small as 0.125" diameter, traveling at 200 IPM at 10,000 RPM. Rough and final machining of the remaining doors required 80 hours each.

With the successes of mill/turn-multi-tasking machining technology, the ME has invested in additional machine tools of this type, the newest of which features twin spindles for turning and milling on opposite sides of a component and a lower turret for simultaneous turning operations.

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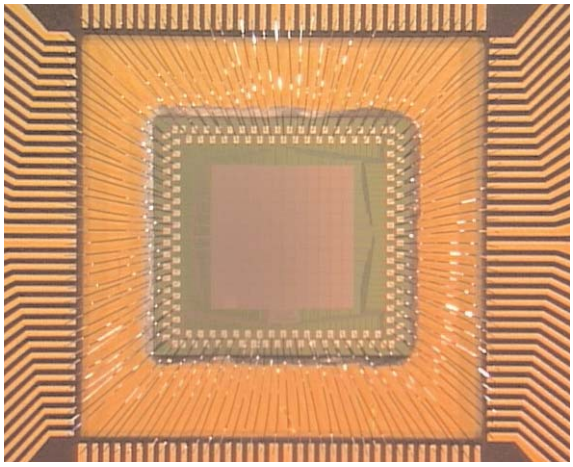
High Reflectivity MEMS Mirrors Delivered

The development of microelectromechanical systems (MEMS) has recently taken a step forward by meeting a program deliverable requirement. This includes the fabrication of multiple high density, functional arrays of flat, reflective, individually addressed MEMS mirrors. The capabilities of these mirrors potentially enables a variety of aeronautical, space and weapon systems. Immediate application of mirror arrays involves use in a closed-loop adaptive optics system to correct for aberrations in circular laser beams. Future development for this program includes improved addressing techniques, multi-level packaging processes and design optimization.

The program has benefited from collaboration with the Thin Film, Vacuum & Packaging department. Building on previous research, low stress (< 1 MPa) metal thin films have been integrated with polysilicon MEMS devices made using the Sandia SUMMIT process. Engineered high reflectivity gold coatings have been developed to boost reflectivity to desired levels (~96 % reflectivity at λ = 1.55 µm) without compromising the flatness of a released silicon mirror base (specified to λ/30 or better). This is challenging, because the polysilicon mirror base is extremely thin (~ 2.25 µm) compared with its width (several hundred micrometers). Advanced thin film technology has been used in tandem with the department's expertise in packaging. Die were attached into a 144 pin grid array; electrical connections involved alu-



The completed mirror

Direct Write Technology

The Electronic Fabrication department is purchasing a new Direct Write system that will enable it to handle parts up to 24 inch by 24 inch by 10 inches in height. This system will enable the department to directly write electronic traces and passive components onto, and embedded into, 3-D structures. A Sandia-funded R&D program has demonstrated the ability to write complex circuitry on 3-D stereolithography parts (see Figs. 1 and 2). This new technology will allow for the rapid prototyping of electromechanical parts.

Figure 1

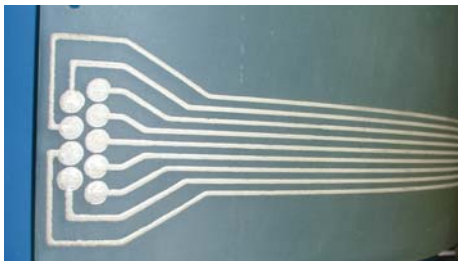


Figure 2

minum wire bonding. Packaged MEMS mirror arrays have been delivered to the customer, and mirror performance has been demonstrated.

The team responsible for this development is comprised of several Sandia National Laboratory employees involved with MEMS design, processing and packaging as well as advanced thin film engineering. This includes the Principal Investigators, E. Garcia and J. DeBassige (Electromechanical Engineering), and department contributors K. Archuleta, R. Torres, B. Wroblewski, C. Hodges, K. Peterson and D. Adams.

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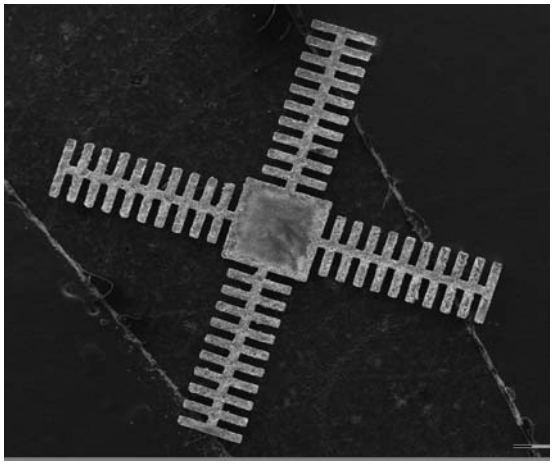
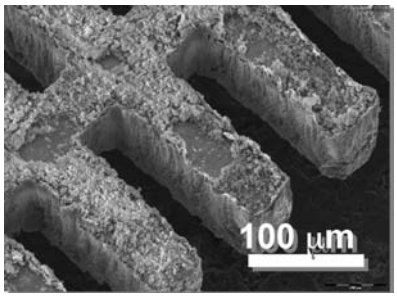
Scanning New Territory with Femtosecond Laser

Continued from page 1

heat influence that could potentially damage or detonate the material. Another innovative effort has begun to investigate the use of the femtosecond laser to selectively release MEMS devices. A new Advanced Manufacturing LDRD will explore femtosecond laser micromachining as a compliment to the LIGA microfabrication process.





The process parameters for this mesoscale windmill were a velocity of 0.42 mm/s; 25 micron layer increments; 125 mm thick SS316 foil. The secondary arms are 100 µm wide with 100 µm spacing. The processing time was 30 minutes.

The Ceramics and Glass department has created both linear and curved optical waveguides buried in glass. As an extension of the optical waveguide, two components have been made, an optical splitter and a directional coupler which couples light from one waveguide to another by means of electromagnetic coupling. In addition, the department is one of the first groups to report on laser induced birefringence in optically transparent media. Laser induced birefringence holds the potential for controlling the polarization of light passing through waveguides. In the future, the department will be working with the microsystems departments to examine the possibility of creating a direct write ring laser. Finally, some initial work has been done using Foturan glass to create buried channels and structures. By exposing specific regions in the Foturan glass to the laser radiation, three dimensional structures (such as micro valves and reaction chambers for sensor applications) can potentially be etched inside the glass.

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Seven Mfg. S&T Center Employees Attend JOWOG-23 Symposium in the UK

Eighteen Sandians from various Centers participated in the recent Neutron Generator/External Neutron Initiator Joint Working Group-23 (JOWOG-23) Symposium at AWE Aldermaston in the UK in June 2004.

A broad range of papers relating to Neutron Generator technology were presented by both the UK and US authors. The primary science and technology areas involved were Neutron Tubes, Active Ceramics, Modeling, and Neutron Generators (both Ferroelectric and Electronic).

Mfg. S&T Center staff were Ron Goeke from Thin Film, Vacuum and Packaging; Tim Gardner, Steve Lockwood, Roger Moore, Scott Reed, Chad Watson, and Pin Yang from Ceramics and Glass. They presented a total of seven papers. The proceedings from the Symposium are being published in two volumes, one containing the UK papers and the other the US papers.

Separate breakout discussions were held to facilitate specific areas of future R&D collaboration between US and UK staff.

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Acetone Reduction

The Ceramics and Glass department performs War Reserve production of active ceramics components in support of the Neutron Generator production mission at Sandia. We are using Lean/Six Sigma methodology to improve existing production processes in order to increase efficiency. One example of these efforts is an individual "Green Belt Project," which had a goal of improving the efficiency of an acetone cleaning process for current stack piece parts. This effort melded Pollution Prevention concepts with the waste elimination focus of Lean Manufacturing in a synergistic fashion.

The cleaning process involves using an acetone bath to remove a temporary silver film from current stack piece parts. This process has stringent quality requirements and changing this process in any way required many individuals to be in full agreement. The process originally required 30 liters of acetone and nine hours of labor time for each production lot. Approximately ten lots are cleaned every year. According to established procedures, each primary acetone rinse could only be used a maximum of two times before disposal as hazardous waste. The goal of this Green Belt Project was to streamline the procedure to significantly reduce acetone purchases, labor time, and hazardous waste while continuing to meet the current standard for part cleanliness.

Through a series of rigorous surface analysis tests performed on the ceramic piece parts, it was determined that each part would meet the specifications for cleanliness with significantly fewer acetone rinses. Instead of using the two acetone baths a maximum of two times, each bath can now be used up to 14 times before it becomes too contaminated to properly clean parts and has to be disposed of as hazardous waste. The annual net savings achieved from these process changes is estimated to be approximately $17,000. Similar methods could potentially be used by any facility involved in weapons work. Since reduction of hazardous waste generation is a logical step in improving process efficiency, this example demonstrates how easily Pollution Prevention can be integrated into Lean/Six Sigma process improvement efforts.

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Production-Ready Hardware for DoD Protection Programs

Engineers in the Security Systems and Technology Center recently teamed with the Electronics Fabrication department to deliver base security production hardware in support of the DoD Installation Protection Programs. The production hardware, called a Gate Node Box (GNB), provides the centralized network service to sensors, cameras, and local control and alarm centers. The GNB collects all of the gate alarm data and transmits the data to a central command center, but it can also operate the gate system in standalone mode if needed. Once built, the GNB units are configured and checked out at the test site at Kirtland AFB with sensors that detect radioactive sources from moving vehicles.

Gate Node Box in test installation

The GNB production units were designed with the field engineer in mind. Components are physically laid out to facilitate performance, safety, and ease of trouble shooting the entire system. Commercial components were researched and designed into the GNB to ensure easy replacement and availability. The GNB also allows for future expansion if the GNB is called upon to support other sensors such as Weather, Chemical, Explosives, Biological, and Water Contamination. To expedite future orders, the GNB production package can be easily implemented and outsourced as part of the Electronic Fabrication department's design-for-production initiatives under Phil Gallegos, manager.

The engineering and fabrication team members who advanced the GNB design from prototype to production are Steve Sanderson, Dennis Lee Carlson, and Jacob Barrandey. Steve is an electrical engineer from the Security Systems and Technology Center, Dennis is a graduate of the Advanced Manufacturing Trades Training Program (AMTTP), and Jacob has been in the program for a year.

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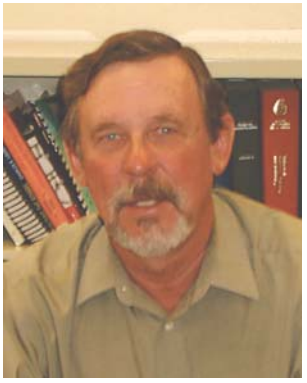
Insider News

In recent years at Sandia, on the order of 15-20 people reach their 40th service anniversary every year. This September, Tommy Simpson (Manufacturing Processing) will celebrate forty years of working at Sandia. Even more amazing is the fact that for all of those forty years, Tommy has worked in positions associated with Sandia's Manufacturing Enterprise.

The machine shop Tommy started working in as a 20 year-old from Quemado, NM was very different from today's operation. In 1964 there was only one NC machine that worked off tapes and was used to drill holes, the cost of projects wasn't considered, there were at least 300 machinists at work, 7-8 branch shops around the Labs, Sandia was at the edge of the city, and MPs (military police) directed the traffic on base instead of stoplights. Tommy became a team leader in 1975 and a manager in 1987 and has thoroughly enjoyed the people he's worked with over the years. In his spare time, Tommy plays polo, ranches, raises horses, and enjoys having his family near.



Tommy Simpson

When asked to define his best time in forty years of work at Sandia, Tommy says that time is right now. The new technology and the caliber of the people in the shops makes Tommy extremely proud of the facility. The ME is exploring new ways of doing business, maintaining quality, and interacting with customers. Every day he learns something new from the Sandians he works with across the Labs. In fact, Tommy has enough projects in mind to last another 5-10 years. He is excited about the future!

—Carol Adkins

A "Beast" of a Wedding Gift

by Ernest Duran

Just a few months ago I was surprised by my wife-to-be with a wedding gift, when a brand new Ultra Classic Cruiser 2003 (100-year Anniversary) Harley-Davidson motorcycle arrived at my residence. As I remember, quite a few people knew of this secret arrival, but they did an outstanding job of not letting me know anything about it. They had me believing that the Harley-Davidson Cruiser actually belonged to one of them. As my fiancée looked at me and told me to sit on the bike, I told her "no, you never sit on another man's bike", she calmly handed me the keys and said "now you can sit on it!"

Ernest Duran (Facilities Management & Operations) and Debbie Duran (Electronic Fabrication) set off on one beauty of a beast of a bike.

I can't express the feeling that came over me when I finally realized that this beautiful piece of artwork was really mine! It was really embarrassing though, not even knowing where the ignition key was located, since I hadn't been on a motorcycle for over 25 years! With a little help from my friends, I finally managed to get it started. My excuse for not taking off for a ride that very moment was that I was a bit rusty when, in reality, I was scared stiff of this larger than life beast!

After an excellent training/refresher course by certified Harley-Davidson instructors, I felt comfortable riding this beast and felt I now belonged to a group of people I always envied. Since many of my friends were already veteran riders, I soon began to realize that this was a group not of notorious people who went around terrorizing the country side, but people with hearts bigger than life and an attitude that said, "We want to improve the image of motorcyclists."

I soon found out that what they said about most riders being just like you and me was true. Riders nowadays are doctors, lawyers, secretaries, working craftspeople and people of all walks of life. I hadn't realized how many people ride just to relax and how many fun people you meet on the road. One of the amazing things I found out, different from driving a car, is that if a motorcycle rider comes upon another motorcycle rider who is experiencing a problem with a bike or anything else, you can be assured that the rider will stop and offer assistance. Riding a motorcycle develops a bond with other riders no matter what brand of motorcycle they are riding. True, we have a tendency to poke fun of people riding Hondas or Kawasakis, Enduros,Yamahas or whatever, but that is done only in fun. When any rider needs assistance, we do not even consider for one moment, the type of motorcycle he/she is riding. In our way of thinking, they are one of us.

Since I've had my bike, I have been fortunate to be invited by other riders to participate in such rides as Toys for Tots and the "Legion Riders" ride to raise money for disabled veterans and their families during the holidays. This feeling of helping someone less fortunate gave me great pleasure and I intend to continue doing this if God's willing. There are numerous bike rallies throughout the country at any given time. I, being fairly new, have not had the opportunity to attend as many as I would like, but we are planning to attend some in the very near future. There are also quite a few swap meets where you can pick up parts, clothing, and just about anything imaginable for you and your bike, at a much more reasonable price then that at the dealership.

I am becoming one with my Harley. I believe that might worry my now wife (Debbie Duran, Electronics Fabrication) that she won't be able to find me a lot of the time—not to worry as she also loves to ride. The feeling of being alone, free and able to go with the wind in your face is something that you need to experience at least once in your life. So, get a Harley and start living !!

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. SAND2004-3841P

Kudos

SkillsUSA
Machining Student Wins Bronze in National Competition

Peter Michel, a student in the machining discipline of the Advanced Manufacturing Trades Training Program, was awarded a Bronze medal in Precision Machining Technology at the SkillsUSA National Championships in Kansas City, MO in June, 2004.

To qualify for the national competition, Peter placed in the top three at Albuquerque Technical Vocational Institute's in-house competition. He then won the state machining championship in April. In preparation for the national competition, he was mentored by Michael McReaken, a Machinist Apprentice at Sandia and a previous New Mexico State Precision Machining SkillsUSA Champion.

Michael McReaken (left) and Peter Michel

The contest consists of individual state champions from across the country competing against each other in 7 different machining skills areas (manual lathe, manual milling, CNC lathe, CNC milling, drill press/surface grinders, process control/inspection, and professional development) and 3 written tests covering machining theory, engineering drawing interpretation, and geometric tolerancing. **Contact: Doug Abrams (505-0844-1124, dgabram@sandia.gov)**

Newsletter Contacts

The MFG S&T Quarterly is published by a team of employees representing the Mfg. S&T Center. Contact any team member if you are interested in submitting an article or would like to know more about joining the team.

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14100 Carla Chirigos
14131-4 Daryl Reckaway
14132 David Gill
14133-2 Linda Kelton
14151-1 Debbie Duran
14152 Rose Torres
14153-1 Gerry Reynolds
14154 Julie Marquez

Apprenticeship Returns to Sandia

In May 2004 the New Mexico Department of Labor, State Apprenticeship Council approved and registered Sandia National Laboratories Apprenticeship Standards. The formulation of the Apprenticeship Standards was a joint effort by representatives of Sandia, The Atomic Projects and Production Workers Metal Trades Council AFL-CIO, Bureau of Apprenticeship United States Department of Labor, and The New Mexico State Apprenticeship Council. There is now a formal Apprenticeship Program for four trades training disciplines (Electronic Fabrication, Machining, Materials Processing Specialties, and Mechanical Measurements).

Sandia has had a long history of Apprenticeship Programs and the Mfg. S&T Center is proud to bring apprenticeship back. There are now forty-eight apprentices participating in this program. There are an additional twenty-seven student interns participating in the feeder program Mutual Education of Skills Training (MEST). The Center currently has eleven apprentices in Electronic Fabrication, seventeen apprentices in the Machining Trade, fourteen apprentices in Materials Processing Specialty Trades, and six apprentices in Mechanical Measurements.

The journey started in 1997 with the creation of The Advanced Manufacturing Trades Training Program (AMTTP) and an important partnership developed with TVI (Albuquerque Technical-Vocational Institute). The AMTTP used the old apprenticeship as its foundation and updated the academic and hands-on training to meet the new technologies of today. The program has expanded its recruiting to other community colleges and high schools and has incorporated the use of skill standards.

The Apprenticeship is 7500 hours of work experience/training and requires an Associates Degree in a related area as a prerequisite for entry into the program. The apprentice works very closely with trained journey persons throughout their training gaining valuable experience and developing manufacturing skills and expertise. Apprentices complete work tours in various areas in the Center. These work tours are designed to impart knowledge of capabilities and processes and to develop the skills in processes that relate to their field.

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New Permanent Employees

Name	Org
Charles Hill	14131-4
Barbara Allison	14133-1
Aaron Otzenberger	14131-4
Michael Maness	14151-1
Troy Gourley	14152
David Calkins	14153-1
George Burns	14154
Joanetta Hanlon	14154
Nelson Capitan	14154-1
Mark Perea	14154-1
Robin Ryan	14154-1
Margaret Rose Sanchez	14154-1
Angel Vega	14154-1

Meet Linda Wood

Linda Wood is the new Sr. Management Assistant to Gil Herrera, the Mfg. S&T Center director. At Sandia for three years, she previously worked in Safeguards & Security as the Corrective Action Tracking System manager. Prior to joining Sandia, she worked for Albuquerque Public Schools in insurance and benefits, and also at La Cueva High School as "Attendance Queen." Prior to that she operated a family owned business in sampling services.

Mother of two teenage daughters and an adult son, she is a Cadette/Senior leader in the Girl Scouts, and recently went on a two-week trip to Yellowstone with sixteen teenage girls where they earned their camping and geology badges. For hobbies she enjoys anything outdoors—camping, fishing, snowshoeing, gardening, and birdwatching.

Linda Wood